Technical report
IN-001/2024

Incident occurred on 17 February 2024 to aircraft Airbus A321, registration D-AISO, in Madrid (Spain)

Please note that this report is not presented in its final layout and therefore it could include minor errors or need type corrections but not related to its content. The final layout with its NIPO included (Identification Number for Official Publications) will substitute the present report when available.

GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES Y MOVILIDAD SOSTENIBLE
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

FOREWORD

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission regarding the circumstances of the accident that is the object of the investigation, its probable causes, and its consequences.

In accordance with Article 5.4.1 of Annex 13 to the Convention on International Civil Aviation; and as provided for in Articles 5.6 of Regulation (EU) No. 996/2010 of the European Parliament and of the Council of 20 October 2010 and Articles 1 and 21.2 of RD 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent their recurrence. The investigation is not intended to attribute any blame or liability, nor to prejudge any decisions that may be taken by the judicial authorities. Therefore, and according to the laws specified above, the investigation was carried out using procedures not necessarily subject to the guarantees and rights by which evidence should be governed in a judicial process.

As a result, the use of this report for any purpose other than the prevention of future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

TABLE OF CONTENTS

ABBREVIATIONS

° ‘ “	Sexagesimal degrees, minutes and seconds
ACP	Audio control panel
AESA	Spain’s National Aviation Safety Agency
AP	Autopilot
ATC	Air Traffic Control (in general)
ATPL(A)	Airline transport pilot license (aircraft)
ATSB	Australian Transport Safety Bureau
BFU	German Federal Bureau of Aircraft Accident Investigation
CAT	Commercial air transport
COP	Co-pilot
CVR	Cockpit voice recorder
daN	Decanewtons
DFDR	Digital flight data recorder
EASA	European Aviation Safety Agency
ECAM	Electronic centralised aircraft monitor
ECCAIRS	European Co-ordination Centre for Accident and Incident Reporting Systems
ECR	European Central Repository
EDDF	Frankfurt Airport
EFIS	Electronic flight instrument system
EGPWS	Enhanced ground proximity warning system
FAA	United States Federal Aviation Administration
F/CTL	Flight controls
FDR	Flight data recorder
FIR	Flight information region
FL	Flight level
ft	Feet
h	Hours
IFR	Instrument flight rules
IR	Instrument rating
JAR	Joint aviation requirements
kg	Kilograms
km	Kilometres
LEMD	Adolfo Suárez Madrid-Barajas Airport
LEZL	San Pablo Airport (Seville)
m	Metres
MHz	Megahertz
MPL(A)	Multi-pilot licence
MSG	Message
N	Newton(s)

Nº.	number
NE	Northeast
NM	Nautical miles
ICAO	International Civil Aviation Organisation
OFF	Off
ON	On
P/B SW	Push button
PF	Pilot flying
PIC	Pilot-in-command
PM	Pilot monitoring
QAR	Quick Access Recorder
SEC	Spoilers and elevator computer
SIB	Safety information bulletin
SOP	Standard operating procedures
UIR	Upper flight information region
UTC	Coordinated universal time
VDL	Valid only with correction for defective far-sightedness
VHF	Very high frequency (30 to 300 MHz)
VOR	VHF omnidirectional range
WS	Wind shear

Technical report

IN-001/2024

Date and time of the incident:	17 February 2024, 10:32 UTC[1]
Place of the incident:	FIR/UIR Madrid, at 88 NM to the NE of LEMD.
Operator:	Lufthansa
Aircraft:	Airbus A321, registration D-AISO (Germany)
Persons on board:	205 (6 crew members and 199 passengers)
Type of flight:	Commercial air transport - International - With passengers
Phase of flight:	En route
Type of operation:	IFR

Date of approval: **27 November 2024**

Synopsis

Summary:

On Saturday, 17 February 2024, an Airbus A321 aircraft with registration D-AISO took off from Frankfurt Airport (EDDF) in Germany for a flight to Seville Airport (LEZL) in Spain.

The aircraft was en route, flying over the Iberian Peninsula at 88 NM NE of Adolfo Suárez Madrid Barajas Airport (LEMD), when the co-pilot suffered a sudden and severe incapacitation while alone on the flight deck. The captain had left the flight deck a few seconds earlier for physiological reasons. A few minutes later, the captain entered the flight deck to find the co-pilot incapacitated and decided to divert to LEMD, where the aircraft landed safely and the co-pilot was taken to hospital.

The investigation has concluded that the cause of the co-pilot's incapacitation was the manifestation of a symptom of a condition that had not previously been detected either by the pilot himself or during the aeronautical medical examination.

This incident has highlighted the benefit of having another authorised person on the flight deck when one of the two pilots leaves for physiological or operational reasons. It has been deemed appropriate to issue a safety recommendation to EASA in this regard.

[1] All times used in this report are UTC. Local time is 1 hour ahead. This is the time at which the co-pilot's incapacitation began.

1. FACTUAL IFORMATION

1.1. History of the flight

On Saturday, 17 February 2024, the Airbus A321 aircraft with registration D-AISO and callsign LH77X, took off from Frankfurt Airport (EDDF) in Germany for a flight to Seville Airport (LEZL) in Spain.

The captain was the PM and the co-pilot was the PF. This was the 4th day of a 4-day rotation for the flight crew. During the previous 3 days, in the captain's opinion, the co-pilot carried out his work according to the company's SOPs, displaying a consistently high level of motivation.

At 10:31 UTC, when the aircraft was en route, the captain left the flight deck and went to the forward lavatory. Prior to this, the captain and the co-pilot had a conversation about the weather conditions and the operation of the aircraft. According to the captain, the co-pilot appeared to be able and alert at that time[2].

When the captain returned from the lavatory at 10:39 UTC, he used the standard entry procedure to access the flight deck[3]. As he was unsuccessful, he tried again, assuming that either he had entered the code incorrectly the first time or that the co-pilot was busy with flight duties. The captain made three further attempts, and a member of the cabin crew made an intercom call to the flight deck. There was no response, so the captain used the emergency access code. Before the emergency access code timer expired, the co-pilot opened the flight deck door manually from the inside.

The captain took control of the aircraft at 10:42 UTC.

As the co-pilot was pale, sweating and moving strangely, the captain called for assistance from the cabin crew. The co-pilot was given first aid by the crew and a doctor, who was travelling as a passenger and diagnosed a possible heart condition. The captain decided to divert to the most suitable airport, which was Adolfo Suárez Madrid Barajas Airport (LEMD), where he landed approximately 20 minutes later.

[2] During the investigation, the crew clarified that, normally, before leaving the flight deck, they ensure that the crew member who will remain alone is in good physical and psychological condition.

[3] The flight deck security door is described in Section 1.6.1

The map on the right shows the aircraft's flight path from the time it took off from Frankfurt Airport until it landed at Adolfo Suarez Madrid-Barajas Airport.

It also shows how the aircraft diverted to the latter airport while flying towards its intended destination, Seville Airport:

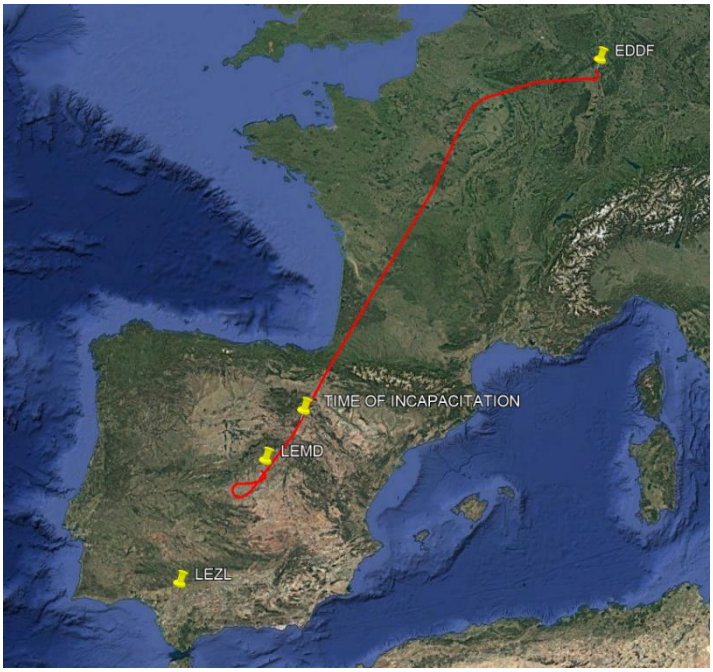


Figure 1: Flight path

Once in Madrid, the co-pilot was transferred to a hospital, where he remained for a few hours.

The operator preserved the data and voice recorders, FDR and CVR, for the incident investigation.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				
Unharmed	6[4]	199	205	
TOTAL	6	199	205	

1.3. Damage to aircraft

No damage sustained.

1.4. Other damages

There was no further damage.

[4] The crew comprised 2 flight crew and 4 cabin crew.

1.5. Personnel information

1.5.1. Information about the captain

The captain, 43 years old, held an ATPL(A) licence, first issued on 18 April 2016. He had an A320 PIC IR rating, effective April 2023 and valid until 28 February 2025.

The captain had received training on situations involving the incapacitation of the other pilot, having undergone the most recent session in January 2024.

The last medical examination was on 3 May 2023 and was valid until 17 June 2024, with a VDL restriction.

1.5.2. Information about the co-pilot

The co-pilot, 38 years old, held an MPL(A) licence, first issued on 18 June 2019. He had an A320 COP IR rating, effective June 2019 and valid until 31 August 2024.

The co-pilot had received training on situations involving the incapacitation of the other pilot, having undergone the most recent session in February 2024.

The last medical examination was on 24 May 2023 and was valid until 1 June 2024. He had no medical restrictions.

1.6. Aircraft information

- Manufacturer: Airbus
- Model: A321-231
- Year of manufacture: 2008
- Serial number: 3625
- Registration number: D-AISO
- Maximum take-off weight: 89000 kg
- Number of engines: 2
- Type of engine: IAE, model V2533-A5
- Information about the owner and operator: The aircraft is registered to Lufthansa Leasing Austria GmbH in the German Aircraft Registry.

The aircraft had an Airworthiness Certificate and an Airworthiness Review Certificate, valid until 25 April 2024.

1.6.1 Flight deck security door

The aircraft was equipped with a security door separating the flight deck from the passenger cabin. In normal circumstances this door remains closed and locked throughout the flight and can only be opened from inside the flight deck.

In order to access the flight deck from the passenger cabin, part of the entry procedure involves entering a standard access code on a numeric keypad near the door. Entering this code generates an audible chime to alert pilots of the request to enter the flight deck. The pilots can authorise entry from inside the flight deck by unlocking the door from a toggle switch on the pedestal.

In an emergency (e.g. if pilots do not respond to requests for entry) the door can be unlocked by entering an emergency code on the same keypad. Entering the emergency code generates a more noticeable sound to warn the pilots of this situation. When this happens, the door unlocks automatically after a specified delay. The flight crew has the possibility to prevent the automatic unlocking of the cockpit door by setting the toggle switch to “LOCK”.

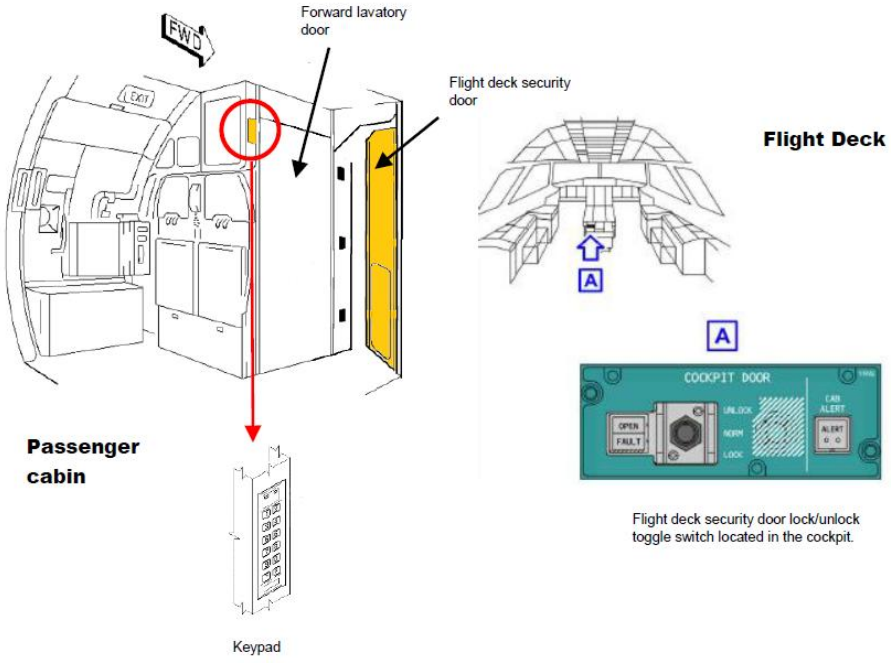


Figure 2: Flight deck security door

1.7. Meteorological information

N/A.

1.8. Aids to navigation

N/A.

1.9. Communications

The communications between the flight crew and air traffic controllers deemed relevant to the investigation into this incident, are included in this section. On this flight, the captain was responsible for communicating with the air traffic controllers.

At 10:24:34 UTC (see 1 in Figure 3), minutes before the captain left the flight deck, the controller of the PAU sector at UIR Madrid contacted the aircraft crew to find out if they had encountered any turbulence at their flight level, FL350. The captain replied that only “light chop”.

At 10:32:06 UTC (see 2 in Figure 3), the incapacitation of the co-pilot occurred.

Subsequently, at 10:34:51 UTC (see 3 in Figure 3), when the co-pilot was alone on the flight deck, the controller made three attempts to contact the crew to transfer control of the aircraft to the next en-route sector, the TLU. There was no response from the co-pilot as he was incapacitated.

At 10:35:31 UTC (see 4 in Figure 3), the controller of the PAU sector contacted the TLU sector, at the same time as another Lufthansa aircraft contacted the TLU sector. Upon hearing the callsign, the controller of the PAU sector assumed that it was the one involved in the incident (the controller of the TLU sector initially mistakenly addressed the other Lufthansa aircraft with the call sign LH77X).

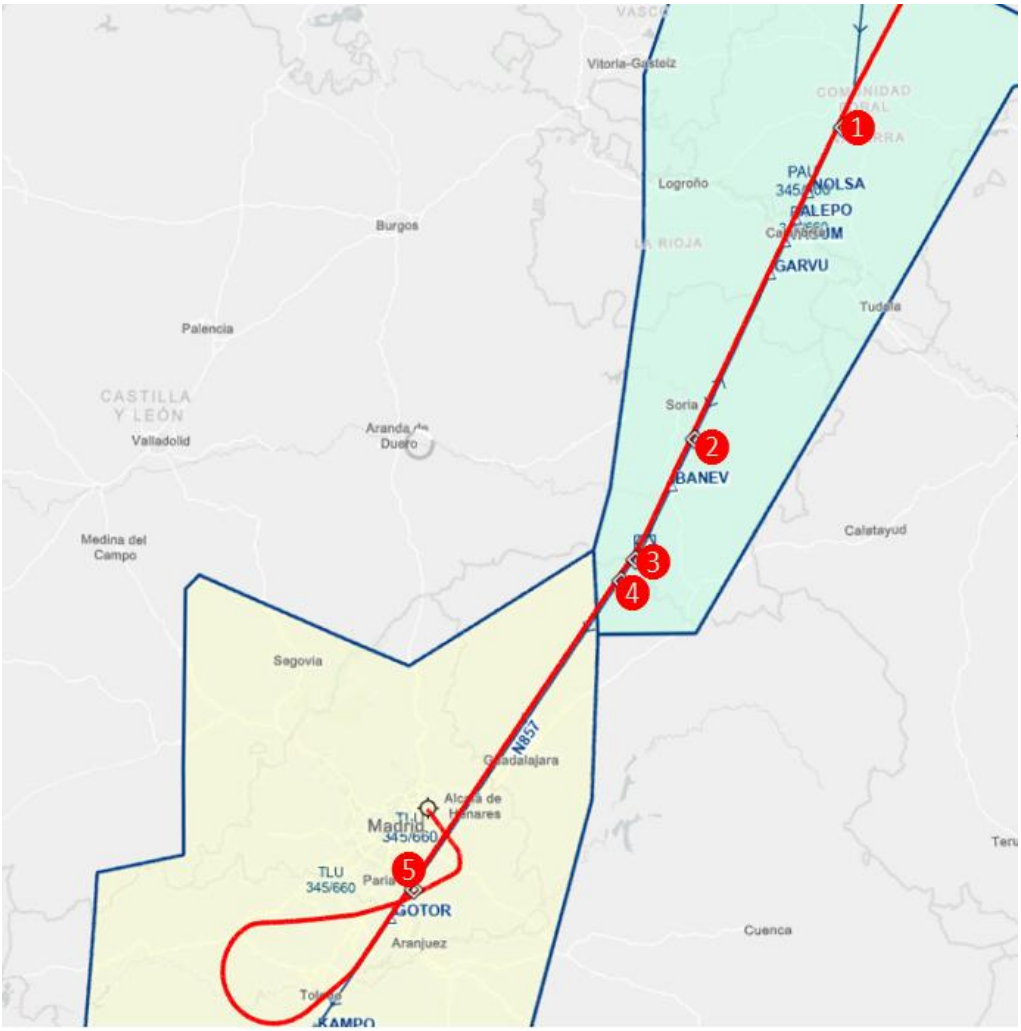


Figure 3: Flight path of the aircraft in the PAU (green) and TLU (yellow) sectors

The next communication with ATC occurred after the captain returned to the flight deck. He contacted the PAU sector controller at 10:43:51 UTC (see 5 in Figure 3) to ask to descend, explaining that they had a medical problem on board, and requested vectors to LEMD. The aircraft was transferred to the TLU sector frequency. Subsequently, it declared a medical emergency and requested the service of an ambulance. The air traffic controllers coordinated with the airport manager to facilitate medical assistance, assigning the aircraft to a parking stand near the runway and arranging for an ambulance to meet it on arrival.

1.10. Aerodrome information

The aircraft diverted to Adolfo Suárez Madrid Barajas Airport, ICAO code LEMD. The nearest town is 13 km to the southwest. The aerodrome's elevation is 609 m, and it has 4 runways: 14L/32R, 14R/32L, 18L/36R y 18R/36L. Between 07:00 h and 23:00 h, the preferred configuration is the North Configuration, in which arrivals are on runways: 32L/32R.

The aircraft involved in this event landed on runway 32L and was assisted by a “follow-me” vehicle to parking stand nº. 10, where an ambulance was waiting to attend to the co-pilot.

The runway 32L threshold, zone G4 and parking stand nº. 10 assigned to the aircraft are marked on the plan on the right.

Figure 4: Image of LEMD airport

1.11. Flight recorders

The aircraft was equipped with a flight data recorder (DFDR) and a cockpit voice recorder (CVR), which recorded the last 25 and 2 hours of flight, respectively.

- The flight data recorder (DFDR) was from the manufacturer L3 Avionik Products, part number 2100-4043-02 and series number 000542476.

- The cockpit voice recorder (CVR) was from the manufacturer L3 Avionik Products, part number 2100-1020-02 and series number 000142679.

The content on both recorders was downloaded at the facilities of the BFU. The information on the Quick Access Recorder (QAR) was also made available to the investigation.

This section sets out the content of the recorders in phases and includes any relevant conversations and sounds recorded on the CVR.

The captain leaves the flight deck.

At 10:31:30 UTC, the flight deck door closed. This was the moment when the captain left the flight deck to use the lavatory. Moments before, the crew had a conversation regarding the expected weather conditions and the operation of the aircraft, in which the co-pilot acted normally.

The aircraft was flying over the Iberian Peninsula at FL350, between the GARVU and BANEV waypoints on airway UN857, approximately 293 NM from its destination, LEZL. (LEMD airport was 88 NM away). The autopilot and autothrust systems were engaged.

Incapacitation of the co-pilot

At 10:32:06 UTC, sounds consistent with the co-pilot experiencing a sudden and severe incapacitation began to be recorded. Over the next 46 seconds, the following was recorded:

- The disconnection of SEC[5]3, which was accompanied by the activation of the Master Caution together with the ECAM SEC3 FAULT warning and the F-CTL page on the ECAM systems display, with spoilers 1 and 2 being unavailable.
- Sudden increase of force on the right pedal, which reached 488 N. The action on the right pedal generated the STOP RUDDER INPUT[6] warning and triggered the activation of the Master Warning.
- The weather radar operating mode changed from WX+T to TURB[7]
- The morse identification of the VOR BAN began to be heard[8].
- The ATC MSG light and its associated audible alert were activated.

[5] The A321 is equipped with three SECs (Spoiler Elevator Computers), which form part of the seven A321 flight control computers. They are responsible for spoiler control and standby control of the elevator and stabiliser. The pushbutton that activates and deactivates SEC number 3 is located on the overhead panel, on the right-hand side. Its deactivation leads to the warnings described above and the loss of spoilers 1 and 2.

[6] The 'stop rudder input' warning is generated when inappropriate rudder pedal inputs are detected in cruise at high speed. It leads to the activation of the Master Warning.

[7] The different weather radar operating modes are selected by a rotary mode selector (WX, WX+T, TURB and MAP) located on the pedestal between the two pilots.

[8] To hear the Morse identification of the VOR radio aids the corresponding reception knob on the audio control panel (ACP) located on the pedestal must be pressed. Each pilot has his own ACP.

The image of the flight deck below shows the position of the controls and switches that the co-pilot inadvertently operated during the first 46 seconds of the incapacitation:

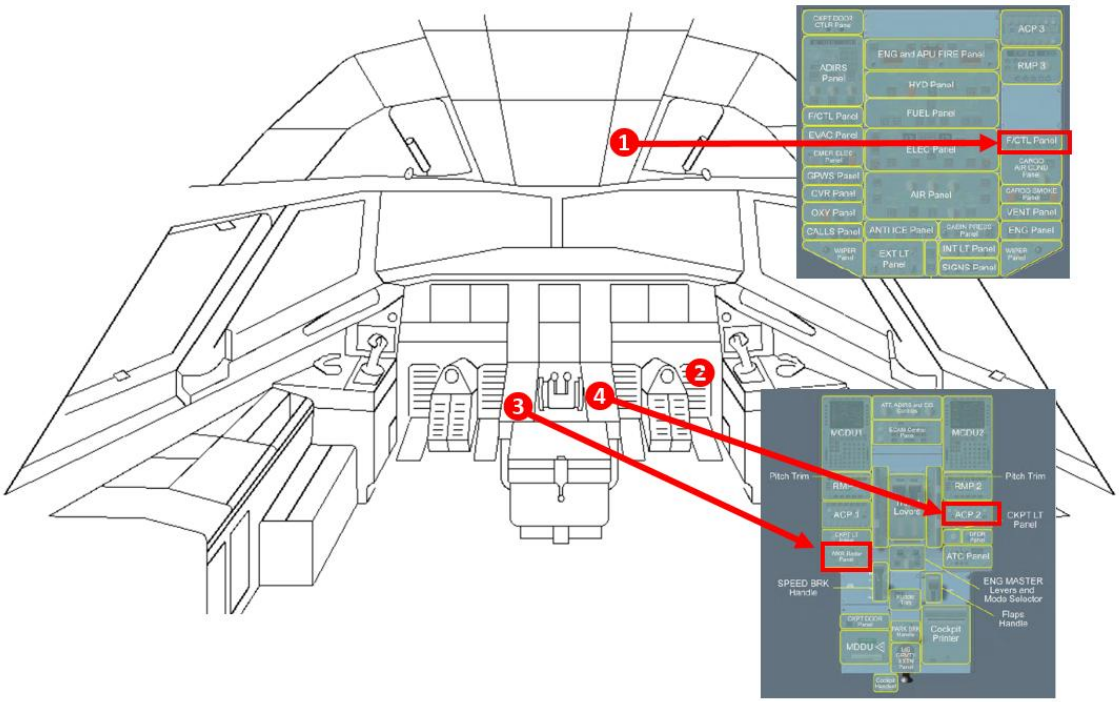


Figure 5: Co-pilot's involuntary actions while incapacitated

	Time in UTC	Event
1	10:32:15	SEC 3 P/B SW in OFF
2	10:32:19	Sudden increase in force on the right pedal
3	10:32:29	*EFIS_Radar/EGPWS OP MD* changes from WS+Turbulence to Turbulence, and remains in that setting until the end of the flight
4	10:32:49	The morse identification of the VOR BAN begins to be audible

The autopilot and autothrust systems remained engaged. The action on the right pedal caused a 5º roll and a 2º heading change, which were compensated for by the autopilot[9]. The aircraft continued to fly the planned route and, after the BANEV waypoint, continued towards the BAN VOR, turning towards the GOTOR waypoint at 10:34:11 UTC, following the airway.

The captain's return to the flight deck.

From 10:39:27 UTC, the captain attempted to enter the flight deck following standard procedure up to five times without success. At 10:40:47 UTC, the cabin crew attempted to contact the co-pilot, again without success. After which, at 10:41:52 UTC, the captain used

[9] To disengage the autopilot with a rudder pedal input, the rudder pedal input should be higher than 10° compared to the rudder trim value and the associated effort to reach this pedal deflection (with the autopilot engaged) is between 45 and 50 daN.

the emergency procedure to open the flight deck door, gaining entry to the flight deck at 10:42:04 UTC.

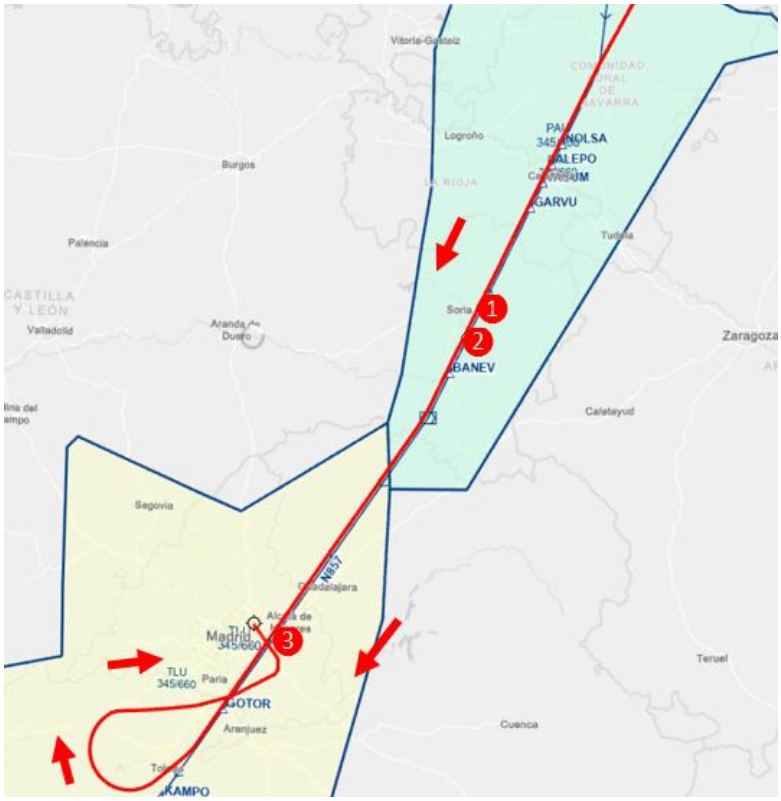


Figure 6: Flight path of the aircraft on the ENAIRE route map

	Time in UTC	Event
1	10:31:30	The captain leaves the flight deck
2	10:32:06	Incapacitation of the co-pilot begins
3	10:42:04	The captain enters the flight deck

The co-pilot was treated in the galley by a doctor who was travelling as a passenger on the aircraft and did not return into the cockpit for the rest of the flight.

After being informed of the medical diagnosis, the captain made the decision to divert to the nearest airport, declared a medical emergency, and requested the service of an ambulance. He landed without further incident.

The information extracted from the FDR is depicted graphically in Section 5, Annex I.

1.12. Wreckage and impact information

N/A.

1.13. Medical and pathological information

During the flight, the co-pilot suffered a sudden and severe incapacitation due to a seizure disorder[10] that prevented him from continuing to perform his duties on board.

As a precautionary measure, following the incident, his medical certificate was suspended until the reason for his seizure disorder was determined.

The sudden and severe incapacitation was the symptom of a neurological condition that had not been detected either by the affected person himself or in the previous aeronautical medical examinations.

Detection of the disease during aeronautical medical examinations

During the investigation, AESA's aeronautical medical service was contacted for information about the detection of the illness that caused the co-pilot's incapacitation during aeronautical medical examinations. According to them, the co-pilot's illness would only have been detectable in a medical examination if his symptoms had been present at the time of the examination or if they had manifested themselves beforehand.

This illness is disqualifying for obtaining or maintaining medical fitness to fly.

1.14. Fire

N/A.

1.15. Survival aspects

The co-pilot suffered a sudden and severe incapacitation that prevented him from continuing to perform his duties on board. He was treated in the galley by a doctor who was travelling as a passenger on the aircraft and did not return into the cockpit for the rest of the flight. After being informed of the medical diagnosis, the captain made the decision to divert to the nearest airport, declared a medical emergency, and requested the service of an ambulance. The air traffic controllers coordinated with the airport manager to provide the aircraft with a parking stand close to the runway and the availability of an ambulance on arrival. Once on the ground, the ambulance transported the co-pilot to hospital.

After the captain had left the cockpit and the co-pilot suffered the sudden and severe incapacitation, the aircraft flew for about 10 minutes in the cruise phase with the autopilot engaged but without additional supervision by either pilot.

[10] The ICAO Manual of Civil Aviation Medicine classifies the different medical incapacitations. Seizure disorders are included in the group of neurological conditions or disorders. A seizure is defined as *an abnormal paroxysmal excessive discharge of cerebral cortical neurons.*

1.16. Tests and research

1.16.1. Interview with the co-pilot of the aircraft

The co-pilot stated that he had lost consciousness and that he couldn't remember when. Before that, he remembered flying over Zaragoza and, the next thing, he was being attended to by the cabin crew and a doctor, who was travelling on the aircraft as a passenger.

The loss of consciousness was so sudden that he was unable to warn the other crew members of his incapacitation.

1.17. Organisational and management information

N/A.

1.18. Additional information

1.18.1. SIB No. 2016-09

After Germanwings accident on 24 March 2015, EASA issued SIB No.2015-04 on 27 March 2015[11]. The reaction to this SIB was rather polarised, with most of the airlines that were already having such policy in place having no objection. Others quickly changed their policy and implemented the recommendations of the SIB. Some airlines were fiercely against it and did not implement them. Their argument was that it introduces higher risks, from a security perspective, than the ones it mitigates.

Within a year, EASA reviewed the implementation of SIB 2015-04[12] and, after receiving feedback on the challenges involved in its implementation, decided to withdraw the SIB and to replace it with SIB No. 2016-09 *"Minimum Cockpit Occupancy"*[13], published on 21 July 2016.

SIB No. 2016-09 recommends that commercial air transport operators of large aeroplanes equipped with a secure flight crew compartment door assess the risk and determine whether they need to implement a two-person flight deck policy. The SIB provides guidance to operators on assessing the risks and defining mitigating measures, including the functions of the authorised person on the flight deck.

In the SIB, EASA explains that several aviation authorities and air operators have been requiring the presence of two authorised persons in the flight crew compartment at all times.

[11] For details, see EASA Safety Publications Tool (europa.eu) This SIB was issued following several accidents that highlighted the risk associated with a flight crew member remaining alone in a cockpit equipped with a security door and being able to lock it intentionally

[12] For details, see Summary of survey results SIB 2015-04 (europa.eu)

[13] For details, see EASA Safety Publications Tool (europa.eu)

EASA adds that there are no indications that such requirement has introduced risks that would outweigh the risk of having a flight crew member deliberately locked out of the cockpit. Currently, EASA is unaware of how many air operators require the presence of two persons on the flight deck at all times.

1.18.2. Procedure established by the operator for exiting the flight deck

In accordance with SIB No 2016-09, the aircraft operator had assessed the safety and security risks associated with a flight crew member remaining alone on the flight deck.

The operator explained that its procedure had changed over time. A few years ago, following this risk assessment, it did require the presence of two authorised persons on the flight deck at all times; i.e., if one flight crew member needed to exit the flight deck, leaving the other crew member alone, a cabin crew member would enter the flight deck during the first flight crew member's absence. However, it subsequently modified its flight procedure when it determined that it did not increase the safety of its operation and now did not require the presence of two authorised persons on the flight deck at all times.

The operator's procedure in effect at the time of the incident is set out below:

> *8.3.4.19 Crew members at their stations*[14]
>
> *During take-off and landing each flight crew member required to be on flight deck duty must be at his station. If the flight is performed by an augmented flight crew, no flight crew member shall vacate a pilot seat for transfer of duties below 10.000 ft above field elevation.*
>
> *During the en-route phase of flight, each flight crew member required to be on flight deck duty has to remain at his station except when his absence is necessary to perform duties in connection with the operation of the airplane or for physiological needs.*
>
> *A minimum of one pilot shall always remain seated at his station, maintain alertness and situational awareness, with unobstructed access to the flight controls.*
>
> *No other person than active cockpit crew shall occupy designated pilot's seats.*

1.18.3. Flight crew incapacitation.

Information on flight crew incapacitation useful to the investigation was gathered from various sources. The findings are detailed in Annex II.

[14] See also EASA Regulation (EU) No 965/2012, point CAT.OP.MPA.210(a) (2)

1.19. Useful or effective investigation techniques

N/A

2. ANALYSIS

In order to exercise the privileges of their flying licences, pilots must periodically undergo medical examinations to ensure that they are fit to fly. This does not, however, prevent flight crew members from becoming incapacitated in flight on rare occasions. In the most severe cases, this incapacitation results in the pilot being unable to continue to perform their duties for the remainder of the flight. On flights operating with more than one pilot, the consequences of these incapacitations are mitigated by the very presence of two pilots on the flight deck, with the other pilot detecting the incapacitation, taking over all duties, and directing the aircraft to the nearest airport. Pilots receive specific training for this type of situation.

However, this case was compounded by the unusual circumstance that the co-pilot became suddenly and severely incapacitated while alone on the flight deck, as the captain had left the flight deck for physiological reasons. During the pilot's absence, the co-pilot inadvertently actuated some of the flight controls and switches on the flight deck. Despite this, the aircraft's automatisms remained engaged, maintaining the flight path. The captain didn't realise that anything unusual was happening until 8 minutes later when, on returning to the flight deck, he asked the co-pilot to open the flight deck security door but didn't receive a response. Two minutes later, after several attempts and using the emergency entry procedure, the co-pilot opened the door manually, and the captain gained access to the flight deck.

An analysis of the following has been undertaken:

- The in-flight incapacitations,
- The co-pilot's medical condition, and
- The barriers that assist in mitigating the consequences of in-flight incapacitation.

2.1 Analysis of the in-flight incapacitations

During the investigation, we reviewed the existing literature on pilot in-flight incapacitation and its causes.

Our research highlighted disparities in the results due to the differing criteria used to analyse in-flight incapacitation. While the Federal Aviation Administration (FAA) identified 39 cases of in-flight incapacitation among American airline pilots over a six-year period, a 2004 study on the annual incapacitation rate of UK commercial airline pilots found that there were 36 incapacitations and 4 sudden deaths, and the Australian Transport Safety Bureau (ATSB) reported an average of 23 pilot incapacitation incidents per year during the period analysed. The CIAIAC, for its part, identified 30 incapacitations in the Spanish Occurrence Reporting System over the last 10 years and 287 in the European Central Repository for the period 2019-2024.

With regard to the causes of these in-flight incapacitations, the most prevalent were:

- For the FAA, the most common causes of pilot incapacitation were loss of consciousness, gastrointestinal issues, neurological events (such as epileptic seizures), and cardiovascular problems (such as myocardial infarctions and cardiac arrhythmias).
- The *"Study on Age Limitations for Commercial Air Transport Pilots"* prepared for EASA and based on data from European National Aviation Authorities, found that cardiovascular conditions were the leading cause of incapacitation, accounting for 19% of cases. This was followed by psychiatric issues at 11%, neurological conditions at 10%, and psychological factors at 9%.
- For UK pilots, in half of the reported medical events, the causes were cardiac or cerebrovascular. In a previous study of in-flight incapacitation in UK public transport operations between 1990 and 1999, gastroenteritis was the leading cause.
- For the ATSB, gastrointestinal illness was the leading cause, followed by laser interference. However, a previous study on medical conditions affecting pilots in flight highlighted cardiovascular events.
- In the study carried out by the CIAIAC, the causes of the in-flight incapacitations were not identified, as the Spanish Occurrence Reporting System contains no information in this regard. Moreover, this shortcoming was also identified in the European Central Repository by the abovementioned *"Study on Age Limitations for Commercial Air Transport Pilots"*.

With regard to the severity of the incapacitations, the studies concluded that most do not pose a serious risk to flight safety. The FAA calculates that the probability of these events resulting in an accident is 0.04. However, it is important to underline the ATSB's conclusion that, based on their data, in most cases, the incapacitation was severe enough for the pilot to be removed from duty for the remainder of the flight, but, fortunately, because of the presence of multi-pilot crews, these incidents generally had a minimal impact on the flight. Therefore, in the event that one of the crew members becomes incapacitated, having multiple crew members present on the flight deck is crucial to ensure that this type of safety event does not constitute a risk to the safety of the flight.

Furthermore, in many of the European Central Repository events analysed by the CIAIAC, the incapacitated pilot was able to inform the other crew members about their psychophysical impairment. However, there were instances where the incapacitation occurred suddenly and was so severe that the affected pilot could not alert the other crew members. In this respect, 3 events were identified in which, while the aircraft was in flight, one of the pilots on the flight deck suddenly became incapacitated and involuntarily acted on the flight controls, disconnecting the autopilot in 2 of those events. Importantly, in all three cases, both pilots were present on the flight deck, and the pilot who remained capable took immediate control, which helped to mitigate the consequences of the incapacitation.

2.2 Analysis of the co-pilot's medical condition.

The co-pilot had a valid medical certificate at the time of the incident. Following this incident, as a precautionary measure, his medical certificate was suspended until the reason for this incapacitation was determined. Subsequently, during the investigation, it emerged that the sudden incapacitation was caused by a previously undetected neurological condition.

During the investigation, we contacted the AESA Medical Service to gather information on the detection of the condition that caused the incapacitation in both the initial and recurrent aeronautical medical examinations. The AESA Medical Service confirmed that the co-pilot's medical condition would not be detectable in any of these medical examinations unless the illness was symptomatic at the time of the medical examination or the pilot had experienced the symptoms previously. Neither of these two conditions applied, as the co-pilot had passed his last medical examination satisfactorily and without any limitations 9 months earlier and stated that he could not recall any similar episode or noteworthy medical condition that would have alerted him to a potential issue. He maintained that he was in good health and was not taking any medication.

In the *"Study on Age Limitations for Commercial Air Transport Pilots"*, and with regard specifically to neurological conditions, it was estimated that for a population of 10,000 pilots, there would be approximately 0.25 seizures per year, i.e. 1 every 4 years. Given that the first seizure cannot be anticipated through medical examinations, designing safety barriers to prevent this type of in-flight incapacitation is difficult.

2.3 Analysis of the safety barriers designed to detect co-pilot incapacitation

Two persons on the flight deck

In a two-pilot operation, when both pilots are on the flight deck, the incapacitation of one pilot can be detected either by the incapacitated pilot themselves, alerting the other pilot to their condition, or by the other pilot recognising the incapacitation of the affected pilot.

However, in this case, despite operating with two pilots, the co-pilot was alone on the flight deck, as the captain was absent for physiological reasons. As a result, there was nobody there to recognise the onset of the incapacitation, and the co-pilot couldn't alert the other crew members because the onset of the incapacitation was so sudden. This meant that the aircraft continued to fly for about 10 minutes in the cruise phase with the autopilot engaged but without additional supervision by either pilot.

Prior to the captain leaving the flight deck, the co-pilot had been behaving normally and was not showing any symptoms that would suggest severe incapacitation was likely to follow. They had a brief discussion about the expected weather conditions and the operation of the aircraft, and, according to the captain, the co-pilot appeared to be able and alert at the time.

Both the EASA regulations and the operator's operating manual provide that one of the two pilots may be absent from the flight deck for physiological reasons when flying in cruise (as was the case), leaving just one flight crew member on the flight deck.

In 2016, EASA, through SIB No 2016-09, addressed the risk associated with a flight crew member remaining alone in a cockpit equipped with a security door and being able to lock it intentionally. As a consequence, it recommended that commercial air transport operators of large aircraft equipped with a security door for cabin access assess the risk and determine whether they need to implement a two-person flight deck policy.

The aircraft operator had assessed the safety and security risks associated with having one flight crew member alone on the flight deck in accordance with the SIB and did not require the presence of two authorised persons on the flight deck at all times as it was deemed that doing so would not enhance operational safety.

However, this event has highlighted the benefit of having another authorised person (usually a member of the cabin crew) on the flight deck when one of the two pilots leaves the flight deck for physiological or operational reasons. If another authorised person had been present on the flight deck, they could have quickly identified the co-pilot's incapacitation, alerted the rest of the crew and opened the flight deck security door so that the captain could swiftly take control of the aircraft.

In view of this incident, we have concluded that operators should take this into account and re-evaluate, from a safety and security point of view, the risks associated with one pilot remaining alone on the flight deck if the other pilot leaves for physiological or operational reasons. A recommendation in this regard is therefore being issued to EASA.

Pilot training

The captain had to take over the duties of both pilots, managing a complex situation with a high workload, and diverting the aircraft to LEMD. The training provided by the operator in this regard proved effective.

Aircraft

The aircraft performed as designed. Despite the co-pilot acting on some of the flight controls and cockpit switches during his incapacitation, the autopilot remained engaged, and the aircraft continued to fly at cruise altitude along the planned route.

3. CONCLUSIONS

3.1. Findings

- The co-pilot had a valid Class 1 medical certificate without limitations.
- During the cruise phase, the captain left the flight deck for physiological reasons.
- Just beforehand, the two pilots had a conversation about the weather conditions and the operation of the aircraft without the captain noticing anything unusual in the co-pilot's behaviour.
- The co-pilot experienced a sudden and severe incapacitation while alone on the flight deck and was unable to alert the rest of the crew to his condition.
- During his incapacitation, the co-pilot inadvertently operated switches and acted on the flight controls.
- The autopilot and autothrust system remained engaged and the flight path was maintained.
- After the captain had left the cockpit and the co-pilot suffered the sudden and severe incapacitation, the aircraft continued to fly for about 10 minutes in the cruise phase with the autopilot engaged but without additional supervision by either pilot.

- In order to gain access to the flight deck, the captain used the emergency code.
- Before the emergency access code timer expired, the co-pilot opened the flight deck door manually from the inside.
- In view of the emergency, the captain took the decision to land at the nearest airport. This allowed the co-pilot to receive medical attention as soon as possible.
- The co-pilot's sudden and severe incapacitation was a symptom of a condition that had not been detected either by the pilot himself or during the aeronautical medical examination.

3.2. Causes/contributing factors

The investigation has established that the cause of the co-pilot's incapacitation was the manifestation of a symptom of a condition that had not previously been detected either by the pilot himself or during the aeronautical medical examination.

4. SAFETY RECOMMENDATIONS

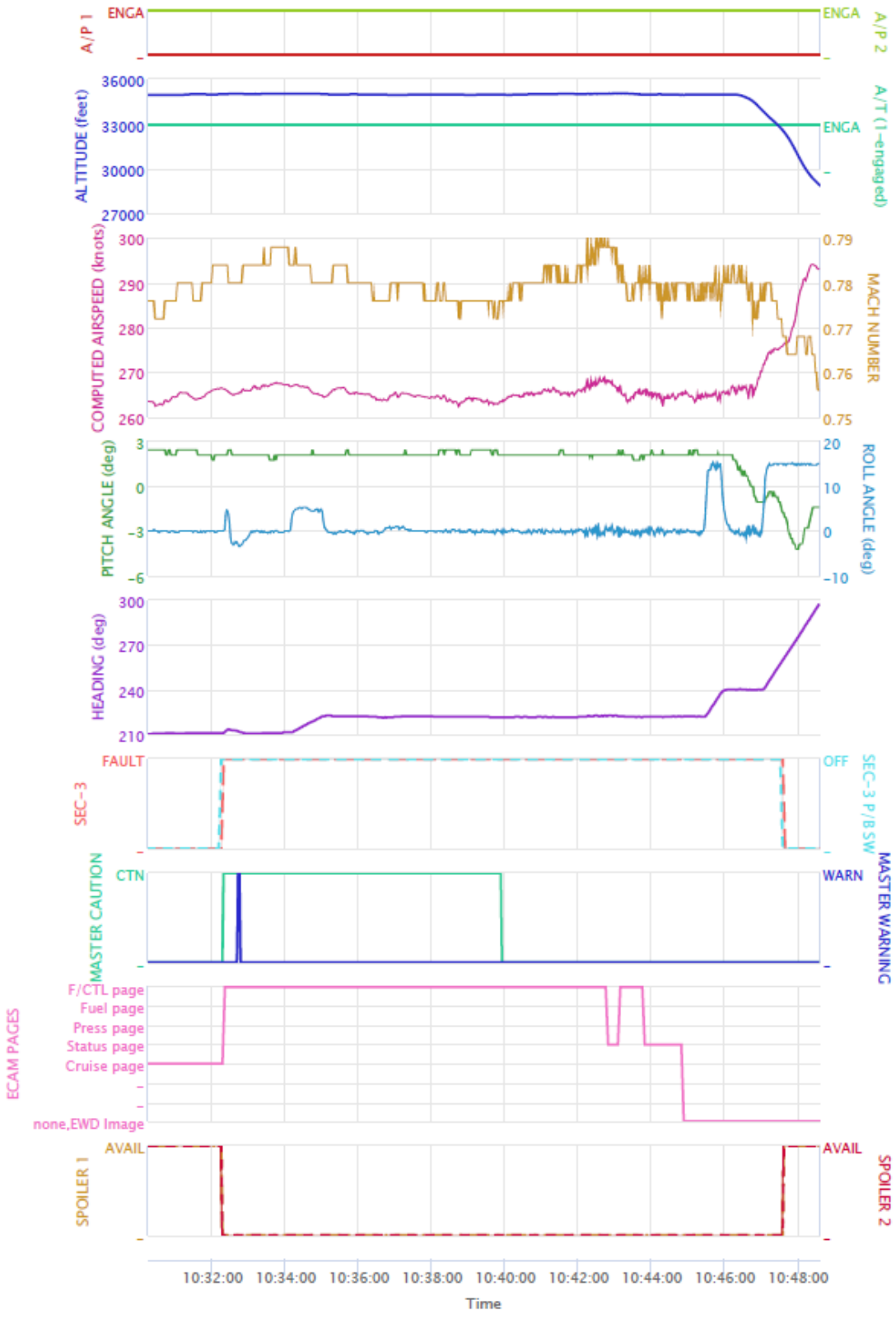
This incident has highlighted the benefit of having another authorised person on the flight deck when one of the two pilots leaves for physiological or operational reasons. If another authorised person had been present on the flight deck, they could have quickly identified the co-pilot's incapacitation, alerted the rest of the crew and opened the flight deck security door so that the captain could swiftly take control of the aircraft.

Following the recommendations of SIB No 2016-09, operators had already assessed the risks associated with a pilot remaining alone on the flight deck when the other pilot left it for physiological or operational reasons. However, in view of this incident, we consider it appropriate to convey the particularities of this incapacitation to operators so that they can take it into account and reassess the risks associated with a pilot remaining alone on the flight deck when the other pilot leaves for physiological or operational reasons. A recommendation in this regard is therefore being issued to EASA.

REC 02/25: It is recommended that EASA inform operators about this event so that they may take it into account and reassess, from an operational safety and security point of view, the risks associated with one pilot remaining alone on the flight deck when the other pilot leaves for physiological or operational reasons.

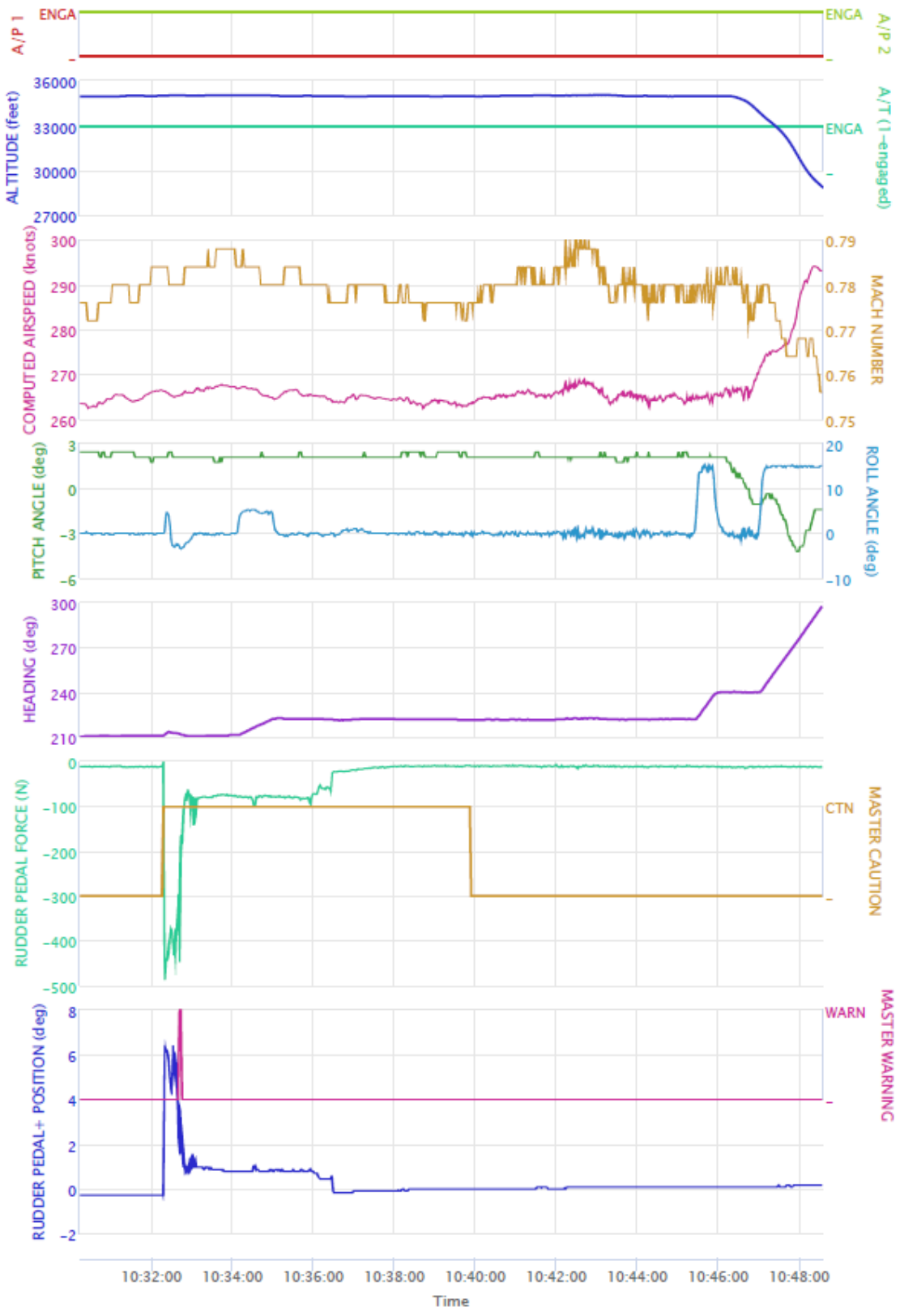
5. ANNEX I FLIGHT DATA RECORDER (FDR) GRAPHS[15]

Disconnection of SEC 3

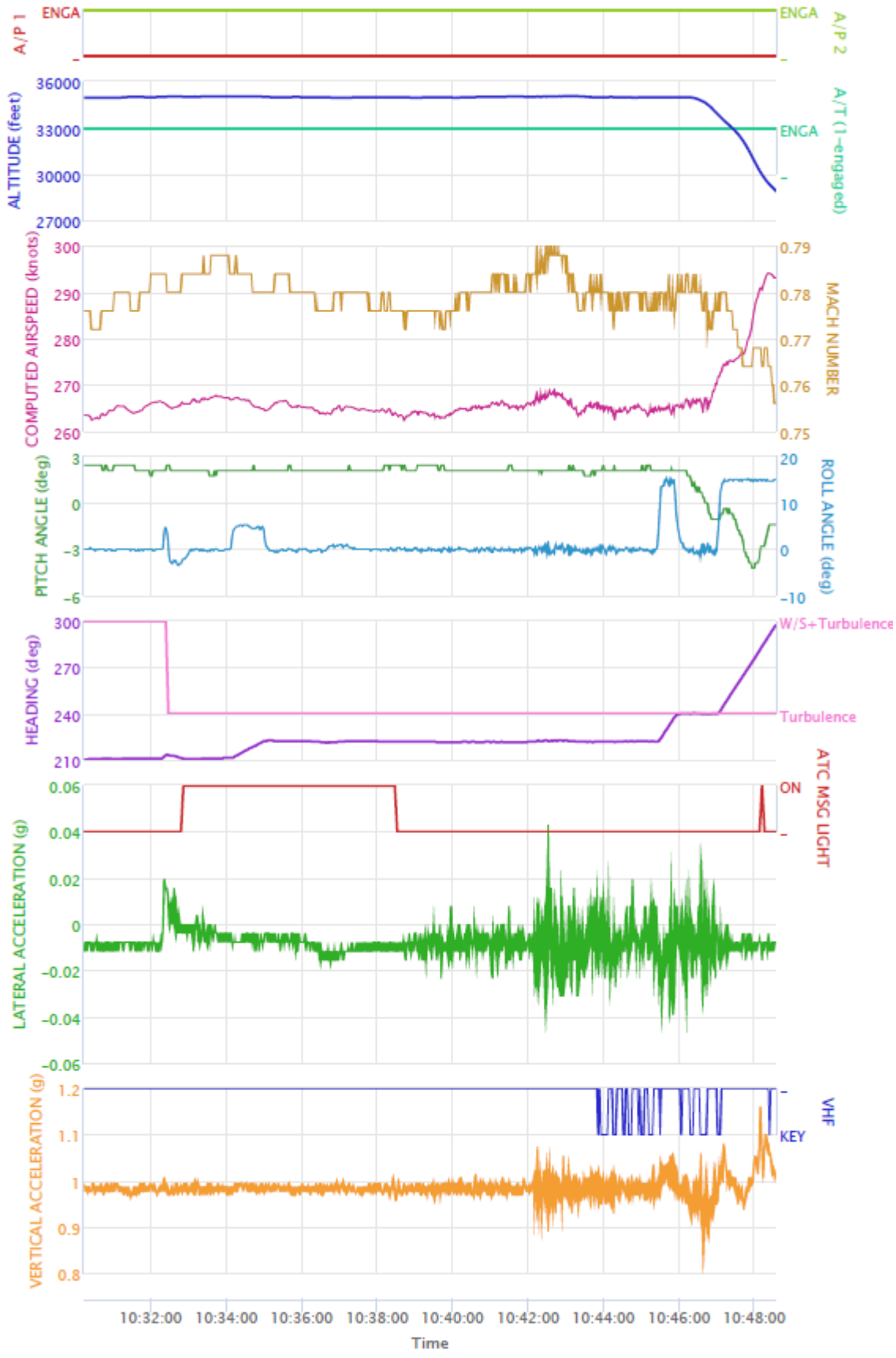


[15] The time indicated on the graphs is UTC.

Rudder pedal actuation



Other parameters



6. ANNEX II FLIGHT CREW INCAPACITATION

6.1. ICAO Manual of Civil Aviation Medicine

In its **Manual of Civil Aviation Medicine** (Doc 8984), **ICAO** explains that pilot incapacitation poses an operational risk and defines it as *"any physiological or psychological state or situation that adversely affects performance"* or *"any reduction in medical fitness to a degree or of a nature that is likely to jeopardise flight safety"*.

The ICAO document refers to a study by the Aeromedical Institute of the US Federal Aviation Administration (FAA) on in-flight medical *incapacitation* and *impairment*[16] of US airline pilots from 1993 to 1998[17]. The study found 39 incapacitations and 11 impairments aboard 47 flights during the six-year period, of which 2 were non-fatal accidents. The rate of incapacitations was 0.045 per 100,000 flight hours, and the rate of impairments was 0.013 per 100,000 flight hours. The probability of these events would result in an aircraft accident was 0.04. The most frequent medical incapacities were loss of consciousness (9), gastrointestinal (6), neurological (6), cardiac (5) and urological (3).

In the same document, ICAO mentions two studies of airline pilots[18] in which more than 3,000 airline pilots participated. The anonymous questionnaires included questions on whether they had ever experienced in-flight incapacitation. In both studies, about 30% responded affirmatively; gastrointestinal symptoms accounted for the majority (58%) of incapacitations, other causes being symptoms of nasal and sinus congestion ("blocked" ear and sinus pain), headaches, including migraine, and fainting or general weakness.

In its document, ICAO also establishes the "two communications" rule as a method of detecting subtle incapacitations before they become operationally critical. The rule states that: "Flight crew members should have a high index of suspicion of a 'subtle' incapacitation any time a crew member does not respond appropriately to two verbal communications, or any time a crew member does not respond appropriately to any verbal communication associated with a significant deviation from a standard operating procedure or a standard flight profile."

6.2. EASA Annual Safety Report

EASA, in its latest safety report, specifically in the **Appendices** of the **Annual Safety Review (ASR) 2024**[19], has identified, among others, safety issues related to human factors

[16] It defined in-flight medical incapacitation as a condition in which a flight crewmember is unable to perform any flight duties and impairment as a condition in which a crewmember could perform limited flight duties, even though performance may have been degraded.

[17] For more details see In-Flight Medical Incapacitation and Impairment of U.S. Airline Pilots: 1993 to 1998 (faa.gov)

[18] For more details see Airline pilot incapacitation survey - PubMed (nih.gov)

[19] For more information see https://www.easa.europa.eu/en/document-library/general-publications/annual-safety-review-2024

(HF) and human performance (HP), for complex commercial air transport (CAT) and complex non-commercial aircraft (NCC)[20]. The safety issues identified are derived only from the European Central Repository (ECR) notifications and cover a period of 5 years (2019-2023).

The figure below shows the number of events relating to human factors (HF) and human performance (HP). It shows that “Impairment and incapacitation”, highlighted in red, is ranked no. 4.

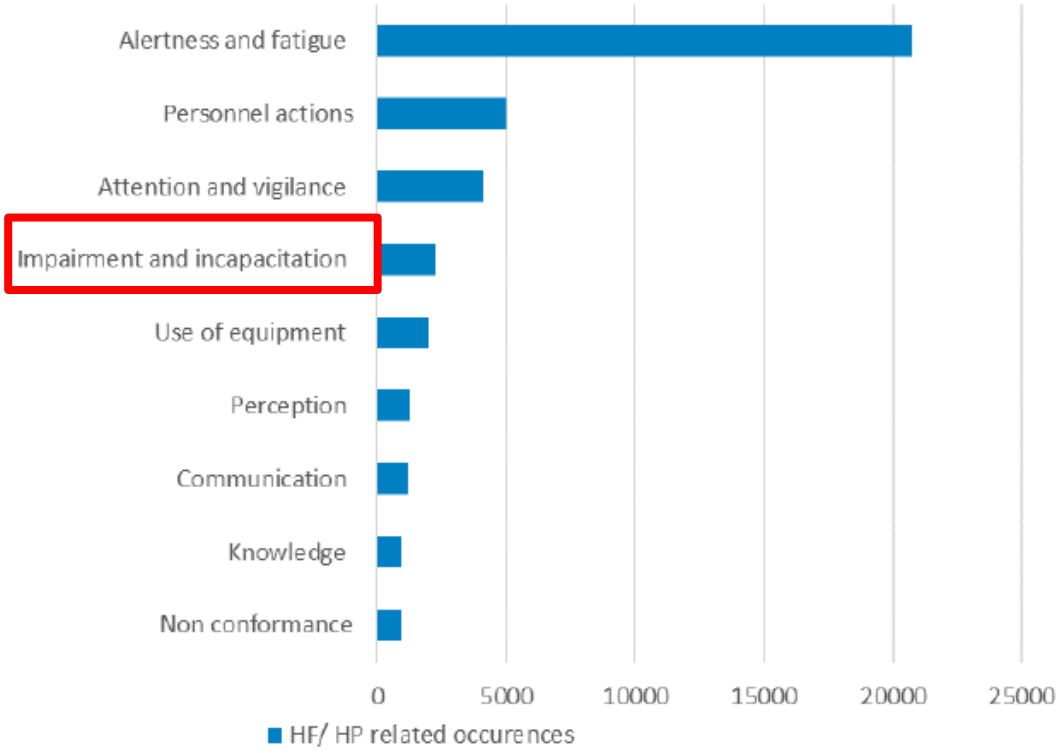


Figure 7: Number of events relating to human factors and human performance

6.3. Severity of flight crew incapacitations

EASA has not included the severity of the medical incapacitations and impairments in its latest safety report.

Recently, the Commission Delegated Regulation (EU) 2020/2034 of 6 October 2020 supplementing Regulation (EU) No 376/2014 of the European Parliament and of the Council as regards the common European risk classification scheme was published.

According to the afore mentioned Regulation, an incapacitation of the flight crew could result in an aircraft upset, the severity score being “X”. In terms of existing barriers to prevent this outcome, the only barrier in place would be: “regulations, procedures and processes”. In

[20] CAT and NCC operations involving complex aircraft are analysed together due to their similar safety issues and the limited data available for NCC

this case, and although not certified as such, the following also acted as a barrier: “aircraft, equipment and infrastructure design”, as the autopilot did not disengage despite the co-pilot's unintentional action. In any case, these are events that should be classified as high risk in ECCAIRS.

6.4. Study on Age Limitations for Commercial Air Transport Pilots

Previously, in 2019, EASA commissioned the study “Age Limitations. Commercial Air Transport Pilots”, from which the following information was extracted:

- The study revealed that the literature on medical incapacitation is scarce, and analysis is hampered by the fact that different denominators are used (flight hours, number of pilots, year...). In addition, there is a lack of uniformity in the definition of incapacitation.

- The study extracted accident and incident data related to flight crew incapacitation in commercial air transport up to 2017 from ECCAIRS. A total of 501 events were identified. Cases due to hypoxia, air quality, physical injury, barotrauma and laser exposure were removed from the sample. The sample also contained 29 events without a narrative, and these were discarded. The resulting sample consisted of 257 incidents of flight crew medical incapacitation, although in 164 cases (which would be 64%), the medical cause of the incapacitation was not included.

  It was recommended that ECCAIRS be improved to enable a more accurate risk analysis of in-flight medical incapacitation, as in most cases, there was no information on age, medical cause and operational consequences.

- Medical evaluations data concerning commercial airline pilots from European National Aviation Authorities was requested. The majority of them were unable to provide it. Reasons given were inaccessibility of the data and inability to retrieve the data. Therefore, it was recommended to improve the system in order to enable a sound evaluation of medical screening results from CAT pilots.

  According to the data provided by a few Authorities, cardiovascular conditions were the most frequent cause (19%), followed by psychiatric (11%), neurological (10%) and psychological (9%) conditions.

  In the particular case of neurological conditions, the study refers to the fact that, for a population of 10,000 pilots, with an annual risk of 0.05% and an average time in the air of 500 h (1/20 of the year), 0.25 in-flight seizures might be expected per year. Although the first seizure cannot be predicted, it is true that the likelihood of suffering a first seizure increases in the presence of cerebrovascular disease[21].

[21] For more details see Flight safety and medical incapacitation risk of airline pilots - PubMed

Current aviation certification specifications for commercial air transport do not prescribe pilot incapacitation probability limits. In a 2-pilot crew, sudden and complete incapacitation of one pilot will result in a significant reduction in functional capabilities and a significant increase in crew workload. The study's authors consider this a major failure condition that must be remote, i.e. the probability must be between $1x10^{-5}$ y $1x10^{-7}$

6.5. UK pilot incapacitation study

Meanwhile, a study of "**The Annual Incapacitation Rate of Commercial Pilots**" was published in **2012**[22]. The study cohort was all professional pilots holding a valid UK/JAR (Joint Aviation Requirements) Class 1 medical certificate and licence in 2004. Three data sources were used to identify incapacitation episodes: the statutory notification of prolonged illness, personal injury or pregnancy to the UK Civil Aviation Authority; the Mandatory Occurrence Reporting (MORs) for in-flight medical incidents; and death certificates. It was found that there were 16,145 professional pilot licence holders in the UK in 2004. Of the notified medical events, 36 were incapacitations; half were cardiac or cerebrovascular. In-flight incapacitations were predominantly of psychiatric cause. There were four sudden deaths. The type of incapacity varied with age. The annual incapacitation rate was 40/16,145, or 0.25%, and the causes of incapacity experienced by British pilots in 2004 were:

TABLE II. PROFESSIONAL PILOT INCAPACITATIONS IN 2004.

Cause of Incapacitation	Number of events	Ages of pilots
Cardiovascular		
Acute myocardial infarction	6	39, 52, 54, 58, 59, 64
Chest pain	2	48, 60
Arrhythmia	3	42, 50, 66
Pulmonary embolus	2	45*, 49
Cerebrovascular		
Stroke	4	33, 42, 50, 59
Subarachnoid hemorrhage	1	48
Other		
Panic attack	3	34*, 35*, 64*
Spontaneous pneumothorax	4	30, 40, 44, 62
Gastric ulcer	1	47
Perforated appendix	1	24
Syncope	1	54
Bowel obstruction	1	48
Biliary colic	1	51*
Migraine	1	47
Prolapsed intervertebral disc	1	52
Epilepsy	2	24, 55
Vestibular disturbance	1	39*
Spontaneous abortion	1	40
Total	**36**	

* Occurred in flight or in the simulator.

Figure 8: Causes of the incapacitations experienced by British pilots in 2004

[22] For more details see The annual incapacitation rate of commercial pilots - PubMed (nih.gov)

This study also refers to the findings of a previous study on in-flight incapacitation in UK public transport operations between 1990 and 1999[23]. Gastroenteritis was the major cause of these incapacitations. 20 out of 127 incapacitations were complete incapacitations due to a loss of consciousness or the inability to continue flight operations for a prolonged period. The causes of these total incapacitations were: 2 cardiac, 4 neurological, 6 gastrointestinal and 8 unknown.

6.6. Australian pilot incapacitation study

The **ATSB** published its study on "**Pilot incapacitation occurrences 2010-2014**"[24] in 2015, concluding that, in the period analysed, an average of 23 pilot incapacitation occurrences reported per year. Nearly 75% of incapacitation occurrences happened in high-capacity air transport operations (about 1 in every 34,000 flights), and the main cause was gastrointestinal illness, followed by laser strikes. In the majority of the occurrences reported, the incapacitation was severe enough for the pilot to be removed from duty for the remainder of the flight. With multi-pilot crews, these occurrences usually had a minimal effect on the flight.

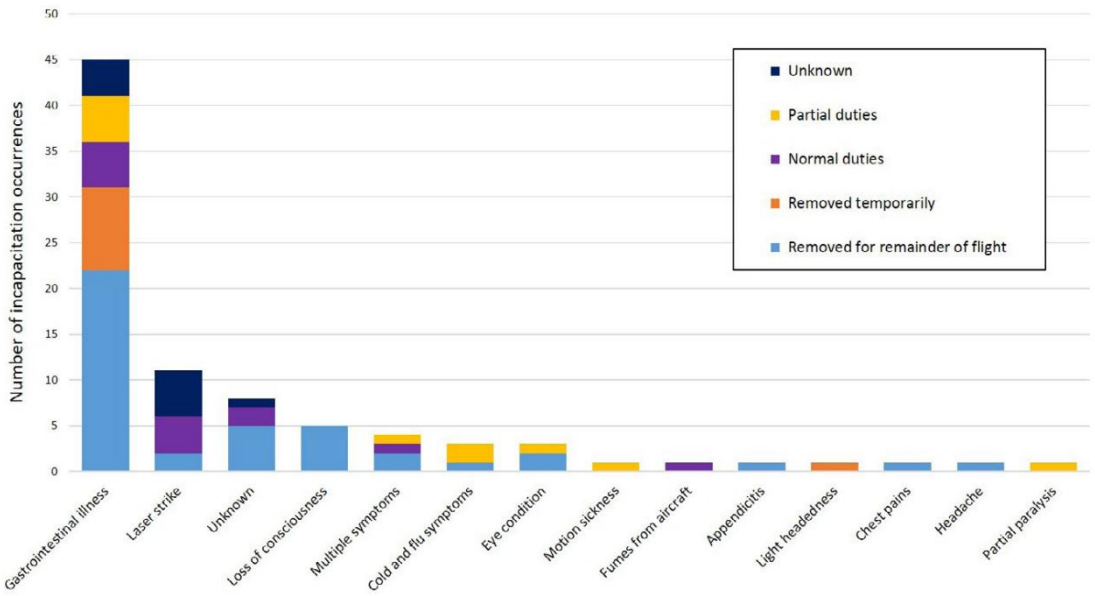


Figure 9: Causes of pilot incapacitation in high-capacity air transport operations (ATSB)

Previously, a review of the Australian Transport Safety Bureau's database of medical conditions affecting pilots in flight highlighted cardiovascular events[25].

[23] Evans A. In-flight incapacitation in United Kingdom public transport operations: Incidence and causes 1990-1999. [Abstract] Aviat Space Environ Med 2002; 73: 242.

[24] For more detail see Pilot incapacitation occurrences 2010–2014 | ATSB

[25] Newman D. Pilot incapacitation: analysis of medical conditions affecting pilots involved in accidents and incidents 1 January 1975 to 31 March 2006. Canberra: Australian Transportation Safety Bureau ; 2007 ; ATSB Transport Safety Report B2006/0170 Jan 2007

6.7. Search for similar incapacitations in the Spanish Occurrence Reporting System

The CIAIAC also consulted the Spanish Occurrence Reporting System in order to identify medical incapacitations reported in commercial air transport in the last 10 years. Those referring to fatigue, tiredness, stress, odours, fumes and laser interference were omitted as they were considered to be an impairment of the pilot's medical fitness rather than an incapacitation preventing the pilot from performing flight duties. 30 incapacitations were identified. The narrative for these events provides little information on the reason for the medical incapacitation, although the other crew member declared an emergency and/or diverted to the nearest airport. The incapacitation rate is 3 per year.

6.8. Search for similar incapacitations in the European Central Repository (ECR)[26]

During the investigation, the European Central Repository of Events (ECR) was searched for events similar to the one investigated.

The search, which covered the period 2019 to October 2024, yielded a wide range of events: incapacitation caused by external causes (lasers, vapours/odours, turbulence, etc.) or illness. In the case of incapacitation due to illness, the cause of the incapacitation is not usually stated in the repository.

A first query yielded 1241 occurrences, of which those with the word *"incapacitation"* in the *"Headline"* tab were filtered accordingly. This resulted in 287 occurrences.

In the vast majority of these 287 events, the incapacitated pilots were able to detect their own psychological or physical decline and alert the rest of the crew. However, in some events, the onset of the incapacitation was suddenly detected by the other pilot on the flight deck. In this respect, the consultation identified 3 events, in which, while the aircraft was in flight, one of the pilots on the flight deck suddenly became incapacitated and involuntarily acted on the flight controls, disconnecting the autopilot in 2 of those events.

[26] In ECCAIRs it is understood as:

- Impairment of psychological or physical fitness. Flight crew able to perform duties with difficulty. It is an event where the flight crew are impaired in their abilities but can still perform their duties with slight difficulty.
- Medical/Incapacitation. Flight crew incapacitation/illness/medical issue. An event involving a flight crew member's inability to perform duties due to illness or other medical issue (excluding injuries).